Report of

Defense Science Board

On

SDIO

BRILLIANT PEBBLES

SPACE BASED INTERCEPTOR CONCEPT

DECEMBER 1989

Office of the Under Secretary of Defense
for Acquisition
Washington, D.C. 20301-3140

OFFICE OF THE SECRETARY OF DEFENSE
WASHINGTON, D.C. 20301-3140

DEFENSE SCIENCE
BOARD

29 DEC 1989

MEMORANDUM FOR SECRETARY OF DEFENSE
DEPUTY SECRETARY OF DEFENSE

SUBJECT: Final Report of the Defense Science Board on Brilliant Pebbles

I am pleased to forward the final report of the DSB on Brilliant Pebbles. The DSB recommends that both the Brilliant Pebbles program at Livermore and the current baseline program in the Air Force be continued until the critical issues are resolved and differences quantified, a process estimated to take about two years. A number of related matters are discussed as well.

We will be pleased to meet with you to discuss the report and stand ready to help in any way.

Robert R. Everett
Chairman

Attachment

Approved for
publication_____

REPORT OF
DEFENSE SCIENCE BOARD
ON
BRILLIANT PEBBLES

INTRODUCTION

At the request of the Deputy Secretary of Defense, the Defense Science Board formed a Task Force to review and assess the interceptor concept development known as Brilliant Pebbles and to report by the end of September 1989. The Brilliant Pebbles Task Force was formed in June 1989 and met six times from June through September with the Strategic Defense Initiative Organization (SDIO), the US Air Force Space Systems Division, the Lawrence Livermore National Laboratory (LLNL), the JASONS, and other groups that are examining parts of the Brilliant Pebbles program.

BRILLIANT PEBBLES

Brilliant Pebbles (hereafter referred to as BP) is an LLNL concept for the space-based layer of the Phase I or kinetic-kill version of the Strategic Defense Initiative (SDI). BP is more than an alternative design of a Space-Based Interceptor (SBI). It is, first, a different architectural approach to the space-based segment than the one that has been consistently pursued by the SDIO for some years and, second, a different approach to the design and exploratory development process.

In the BP design process, costs and weight are ruthlessly controlled; the former by using state-of-the-art components wherever possible and the latter by providing for just-enough capabilities rather than redundant or excessive capabilities for accomplishing the BP mission.

The BP architecture is based on a distributed system comprised of large numbers of small, more-or-less autonomous spacecraft which can perform the functions of surveillance, communications, acquisition, track, target designation and interception. The functions of other system components such as the Boost Surveillance and Tracking System (BSTS) are reduced and in some cases, such as those of the Space Surveillance and Tracking System (SSTS), eliminated. The current baseline SDI architecture design assigns various functions to different system elements, all of which must operate if the system is to work. The baseline SBI design is dependent upon external surveillance for target assignment, and, in some cases,

mid-course updates. BP was originally conceived as highly autonomous. It has become more integrated as work has progressed. The LLNL designers are responding to external suggestions while maintaining autonomous modes, at least for backup.

The greater dispersion and autonomy of BP (at least in backup modes) are clearly advantageous, leading to lowered vulnerability, larger production runs, greater flexibility, and lessened reliance on other Strategic Defense System (SDS) elements.

The design of BP thus far has been examined by a number of competent and independent groups. The examinations have pointed to several areas of possible improvement, but no fundamental flaws have been found in the concept. The design is both innovative and capable, but by no means complete, and is still changing. In fact, it is changing rapidly. This is not bad, but good, because the design is getting better as a result of improvements in technology, constructive criticism, and suggestions from all parts of the SDI community. Several critical issues do exist and have yet to be resolved. In order to keep down weight and cost, some components are marginal in performance and may need upgrading. A plan that identifies how the critical issues will be resolved and when resolution is to occur should be developed.

The work on BP has also had a good effect on the current SBI design, causing the designers to consider BP technology and concepts and to look at new ideas. BP and SBI have been moving closer together as work proceeds.

Our recommendation is to pursue the present Brilliant Pebbles program as is, with the SDIO continuing to fund the BP through LLNL and the SBI through the Air Force. We suggest that this arrangement continue until the advantages and disadvantages of a system architecture based on BP are clearly understood in a quantifiable manner. This should be accomplished as a prerequisite to a Milestone II decision. This is not a simple task and will require a substantial effort. Our estimation is that it will take about two years. This process will also ensure realistic trade-offs between the two approaches, encourage innovation on the part of both groups, maintain a baseline of design and organization that could be implemented if required, and aid both designs to evolve and come closer together, resulting in a possibly different but certainly better design in the future. As we indicated in our 1988 report on SDI, we think the potential for limited defenses on the way to a full Phase I deployment continues to merit attention. We believe, therefore, that the reassessment of the space-based layers of the Phase I architecture should identify the capabilities of a phased deployment against small attacks.

In particular, we do not believe the BP should replace the SBI in the Phase I SDS baseline at this time for two reasons. First, the BP design is neither complete nor stable, nor is there yet a well-defined program acquisition strategy for transitioning BP into system acquisition. A move to adopt the BP concept would therefore create substantial upset and delay. Second, the pressures that would be generated to freeze the BP design would hamper and probably soon end the desirable process of improvement now underway. We do also suggest that LLNL be asked to prepare and keep up-to-date a written description of the design, not just of the BP, but of the entire BP system and how it is to be operated. The BP design should not be frozen, but encouraged to evolve, in order to help others understand and make suggestions and to aid the process of transferring technology to other activities.

PRODUCTION

The production and deployment of large numbers of identical spacecraft is something new, and offers opportunities for innovation and for substantial savings in costs. This opportunity is particularly evident for the BP or other space based interceptor concepts which would exist in thousands. There are also opportunities for new approaches to launching many small satellites. We are concerned that the SBI organizations, which are involved in the acquisition of one-of-a kind or few-of-a-kind satellites, may find it difficult to take full advantage of such opportunities, especially if they are instructed to prepare to build on a definite time schedule. We urge that the SDIO put more real effort into innovative approaches to manufacturing and launch of space-based interceptors, including automated factories, high-rate missile-production techniques and facilities, and factory prepackaged launch and payload vehicles. Such capability could have valuable applications well beyond strategic defense.

FLIGHT TESTS

At the moment both the BP and SBI groups are proposing flight tests. Two sets of tests would be difficult and expensive and we believe unnecessary. It appears to us that these tests are being thought of as demonstrations to show a particular design is satisfactory rather than tests to gather needed knowledge and data for any space based concept. The DSB has been concerned for some time about the lack of basic background and signature information We therefore recommend that any flight

test program be directed primarily toward gathering needed knowledge and information. One properly planned flight test program should provide background and sensor performance data for both SBI and BP, and perhaps for other concepts as well.

A demonstration program could be carried out at a later time, when a choice among alternatives has been made.

COUNTERMEASURES

We suggest that more attention be paid to countermeasures and, in particular, suggest that Red Team efforts be augmented and continue throughout the exploratory period.

SPACE SURVEILLANCE AND TRACKING SYSTEM (SSTS)

Brilliant Pebbles concept analyses have indicated that the SSTS is not needed for boost/post-boost intercepts. SBI contractors seem to agree. This architectural change implies that the SSTS should be rethought based on its other purposes. A rethought SSTS may be less complex and less costly than the current version.

BOOST SURVEILLANCE AND TRACKING SYSTEM (BSTS)

In the fully autonomous mode, the BP does not require the BSTS as presently envisioned in the Phase I SDS baseline. However, a Tactical Warning / Attack Assessment (TW/AA) system is needed whether or not a ballistic missile defense system is ever deployed, and such a system could provide surveillance for BP. In our opinion, the TW/AA mode of operation should be primary and the more autonomous operation of the BP should be a backup. The ability to operate without the BSTS is a very valuable feature which should greatly improve survivability of both the BP system and of the BSTS itself, since it would become a less valuable target.

The current design of the BSTS is matched to a specific SDI concept that results in the satellite being large, complex, technically risky, and raising ABM Treaty problems. Since the SDI concept is still open to change we suggest that the design of BSTS should be reexamined. It may be better to focus development on an improved TW/AA satellite with only those features for SDI that can be defined and justified at this time.

DISTRIBUTED SURVEILLANCE

We are impressed by the Brilliant Pebbles technology and intrigued by the possible use of this and related technology for other purposes. One interesting possibility is the use of BP technology for a distributed boost surveillance system. This idea should be given further consideration, but we believe that the satellite elements should be designed for the purpose and not necessarily derived directly from BP. The sensors, apertures, cooling, and communications should be reconsidered, recognizing that weight is a less serious consideration.

CLARIFYING THE TASK OF THE SDIO

The SDI program appears to suffer from a conflict of purpose. At times the program has emphasized research on new and better technologies and concepts. At other times it has emphasized deployment of a system. These two aims are in competition especially in view of the nature of the existing acquisition process.

There is no reason why the processes of exploring and getting ready to build cannot go on in parallel. There could be at any time a design that could be implemented, i.e., developed and deployed if necessary or desired, and an exploration of alternatives, with a mechanism for getting new and proven ideas into the current design. This is a reasonable approach if clearly delineated, the balance of the activities defined, and the transfer mechanism described. Once a firm decision to develop and deploy is made, the balance would necessarily change, but no such decision is imminent. There is not now a clear direction to SDIO about which of these objectives they are supposed to pursue and if both, as seems likely, the relative emphasis on the two.

We therefore urge that the Secretary of Defense make the relative balance between exploration and building clear to the Director,SDIO, so that his limited resources can be properly employed.

BUILDING vs EXPLORING

The Department of Defense (DoD) has a process for building things. This process, while costly, difficult, lengthy, and often criticized, does get things built. The build process necessarily involves making choices and limiting alternatives.

The DoD does not have an effective process for doing a thorough exploration of alternative technologies and concepts. Exploration is usually done only as a part of the build process, because exploration is expensive and adequate funds are not made available unless a decision to build has been made. The build process, however, tends to shut off exploration, partly to save money and partly to make sure that no new idea will arise to interfere with decisions already made.

Much of the difficulty now being experienced with acquisition stems from setting detailed requirements before adequate exploration has taken place. Lacking the discipline that real knowledge brings to what is doable and how best to do it, these requirements are usually overstated, leading to the delays, overruns, and performance shortfalls that are so common. Perhaps even more serious, the build process fails to take advantage of new ideas and possibilities, both technical and operational. Serious consideration should be given to revising this procedure. We should explore first and then ask whether a buildable system is worth the cost rather than determining what is required first and then struggling to build it, whatever the cost.

This dichotomy is evident in the SDI program. Although the SDI is supposed to be a research & development program, the build model has been applied and has led to fixing the system design too early before adequate exploration of alternative technologies was completed. The system has been divided into components, component descriptions have been set in concrete (or at least in molasses), and innovation has been thwarted despite efforts to encourage it.

Serious consideration should be given to applying the exploratory design approach (of which Brilliant Pebbles is an example) across the SDI, to both the system and the elements. The same approach should be considered for other DoD programs as well. The exploratory approach involves the design by a capable organization with technical depth and experimental resources, operating under a minimum of procedural restraints, and with system specifications not yet fixed.

SUMMARY OF RECOMMENDATIONS

1. Continue to support the Brilliant Pebbles exploratory effort at LLNL directly under the SDIO.
2. Continue the SBI program in the Air Force with encouragement to innovate and to make use of Brilliant Pebbles technology and concepts when desirable.

3. Establish a plan and schedule for resolving the critical issues related to the BP concept and architecture and quantifying the differences between BP and the baseline.
4. Plan for one integrated flight test program directed toward gathering data needed for both the SBI and BP programs.
5. Reexamine the current designs of SSTS and BSTS to make sure they are still appropriate.
6. Consider applying the exploratory process (of which Brilliant Pebbles is an example) to the other elements of the SDI.
7. Determine the relative balance desired between exploration and building in the SDI program, in general, and the space based layer in particular and inform SDIO.

APPENDIX A

TERMS OF REFERENCE

THE DEPUTY SECRETARY OF DEFENSE

WASHINGTON, D.C. 20301

28 AUG 1989

MEMORANDUM FOR THE CHAIRMAN, DEFENSE SCIENCE BOARD

SUBJECT: Terms of Reference - Defense Science Board Task Force on Brilliant Pebbles

I request you to organize a Defense Science Board Task Force to perform a top-level technical assessment of the Strategic Defense Initiative space-based interceptor concept, Brilliant Pebbles.

The Strategic Defense Initiative Organization is considering the future course of its work on the Brilliant Pebbles concept and has arranged for a number of studies of various aspects of the space-based interceptor (SBI) concept this summer. The Task Force should review and evaluate the Brilliant Pebbles concept and make recommendations with regard to:

- The advantages of the concept as compared to the present SBI design,
- The soundness of the required technology,
- The risks and cost in developing the demonstration/validation design, and
- The validity of the demonstration/validation flight experiments.

A report in briefing form is desired by September 1989.

The Deputy Director of Defense Research and Engineering for Strategic and Theater Nuclear Forces will sponsor the Task Force, and Mr. Robert R. Everett will serve as chairman. Mr. Dale E. Moore, DDR&E/S&TNF(DS) will be the Executive Secretary, and LtCol David L. Beadner, USAF, will be the DSB Secretariat Representative

The terms of reference for this Task Force include no assignments that would indicate the Task Force would be participating personally and substantially in the conduct of any specific procurement, or place any member in the position of acting as a "procurement official."

D. J. Atwood

Donald J. Atwood

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The terms of reference for this Task Force include no assignments that would indicate the Task Force would be participating personally and substantially in the conduct of any specific procurement, or place any member in the position of acting as a "procurement official."

DGC

11 JUL 1989

APPENDIX B

TASK FORCE MEMBERSHIP

DEFENSE SCIENCE BOARD
BRILLIANT PEBBLES INTERCEPTOR CONCEPT
TASK FORCE MEMBERSHIP

Task Force Chairman
Mr. Robert R. Everett
Private Consultant

Members
Dr. Solomon J. Buchsbaum
Executive Vice President, Customer Systems
Bell Laboratories

Mr. Vincent Cook
Private Consultant

GEN Russell E. Dougherty (Ret.)
Private Consultant

Mr. Daniel J. Fink
President
DJ Fink Associates, Inc.

Dr. John S. Foster, Jr.
Private Consultant

Dr. George H. Heilmeier
Senior Vice President and Chief Technical Officer, Corporate RDE
Texas Instruments, Inc.

Dr. Robert J. Hermann
Vice President, Science & Technology
United Technologies Corporation

Mr. Fred S. Hoffman
PAN Heuristics Services, Inc.

Mr. Theodore Jarvis, Jr.
The MITRE Corporation

Mr. Walter E. Morrow, Jr.
Director, Lincoln Laboratory
Massachusetts Institute of Technology

Dr. William J. Perry
Managing Partner
H&Q Technology Partners

Executive Secretary
Mr. Dale E. Moore
OUSD(A)/DB

Military Assistant
LtCol David L. Beadner, USAF
OUSDRE(A)/DSB

APPENDIX C

TASK FORCE MEETINGS

DEFENSE SCIENCE BOARD

BRILLIANT PEBBLES TASK FORCE MEETINGS

19-20 June 1989
Washington, D.C.

10-11 July 1989
Livermore, CA

26 July 1989
Los Angeles, CA

31 July 1989
San Diego, CA

22-23 August 1989
Arlington, VA

20 September 1989
Arlington, VA